The Effects of Elevated CO_2 on a Subtropical Scrub Oak-Palmetto Plant Community

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Rising atmospheric CO_2 is expected to alter the global climate (Bolin, 1986). In addition, rising CO_2 will alter key biological processes which regulate the global carbon cycle in the short term of decades to centuries. But without field experiments, we cannot tell how large these effects will be. Experiments being conducted at KSC are intended to address the question of the impact of rising CO_2 on ecosystem processes.

Atmospheric CO_2 concentration directly effects photosynthesis and respiration. These processes cycle more than 20 times more carbon annually between the atmosphere and terrestrial ecosystems than is produced by all anthropogenic processes. It has been estimated that during the past decade, an additional 0.4-2.4 GT. C/yr. has been added to terrestrial ecosystems as a result of the direct effect of rising atmospheric CO_2 on the global carbon cycle since the beginning of the industrial revolution. Such estimates are based on models which are simplifications of natural processes and without field experiments, we do not know how well they will predict the effects of rising CO_2 on the carbon budget of the future. It is particularly important to study the effect of rising CO_2 on the global carbon budget because unless we understand how it is regulated we cannot predict how high future atmospheric CO_2 concentration may rise as a result of burning fossil fuels and deforestation.

We have conducted a 2.5 year (1992-1995) pilot study of the effects of twice ambient CO_2 on native scrub oak-palmetto vegetation at Kennedy Space Center (KSC). This study was a precursor to a long term study (3 plus years) to be conducted by the Smithsonian Environmental Research Center, with funding provided by the US Department of Energy.

The scrub oak-palmetto community at KSC is dominated by three schlerophyllous oaks (*Quercus geminata*, *Q. myrtifolia*, and *Q. chapmanii*) which range from 2-3 m in height and a repent palmetto (*Serenoa repens*). They are fire maintained plant communities that are exposed to a natural fire return cycle of eight to 12 years. The low stature of the vegetation is maintained by a combination of the frequent fires, water stress, and nutrient poor soil conditions (Schmalzer and Hinkle, 1992a, 1992b, 1995). The structure and function of the scrub oak-palmetto ecosystem is quite similar to forests of larger stature, and hence provides a convenient model for investigating a woody system with a mature canopy and mature nutrient cycle with seasonal litter fall. This ecosystem also provides a model to test the effects of elevated CO_2 in a temperate, subtropical system with high irradiance and high evaporative demand.

Open top chamber studies

We used nine 2.4 m diameter plots selected from a native stand of scrub oak-palmetto. Six plots were enclosed with open top chambers of design similar to that used by Drake (1992) in a salt marsh ecosystem near Chesapeake Bay, Maryland, USA. The vegetation in three of the chambers was exposed to twice ambient concentration of atmospheric CO_2 2.5 years. Soil and air temperature, incoming photosynthetically active radiation, relative humidity, soil moisture content and wind speed and direction were continuously monitored using a computer controlled data logging system. Aboveground biomass and shoot phenology were monitored periodically. Root development was monitored using minirhizotrons. Community CO_2 uptake and evapotranspiration were measured by capping the chambers and monitoring concentrations of CO_2 and water vapor entering and leaving the chambers. Leaf measurements of respiration, CO_2 assimilation, and transpiration were also made at intervals throughout the study.

Responses of the scrub oak-palmetto ecosystem to elevated CO_2

Results from the pilot study showed accelerated above ground biomass regeneration, increased water use efficiency, increased carbon assimilation, decreased tissue respiration, and increased the number of fine roots and their penetration into the soil. These findings are similar to those observed in other systems, and provide important information about the behavior of nutrient poor, schlerophyllous communities under an atmosphere of increased concentration of CO_2. An overview of the results obtained to date is provided in Table 1. *Quercus*

geminata and *Q. myrtifolia* showed differential response to CO_2, with *Q. myrtifolia* showing relatively greater response.

Table 1. Summary of results from study of CO_2 effects on carbon cycling in Florida scrub oak-palmetto community. Values indicate % increase or decrease due to elevated CO_2.

	Parameter	Relative Change	Reference
Physiology	Photosynthesis	10 to 20	Vieglais et al.
	Carbohydrate	22	Jacob et al.
	Protein (sol.)	-55	Jacob et al.
	PSII activity	25	Jacob et al.
	Tissue [N]	-20	Drake et al.
	Respiration	-30	Day and Weber
Canopy and Ecosystem	CO_2 exchange	24	Vieglais et al.
	Transpiration	-25	Vieglais et al.
	Water use effic.	53	Vieglais et al.
	Shoots, Leaves	37	Vieglais et al.
	Root production	93	Day and Weber

The effects of elevated CO_2 shown in this pilot study are similar to those reported in other studies. The sustained higher rates of photosynthesis, reduced dark respiration, reduced tissue nitrogen concentration, increased levels of nonstructural carbohydrate, reduced water loss per unit leaf area, increased fine root density all suggest that rising atmospheric CO_2 will increase terrestrial carbon and alter the distribution of carbon among the different pools of carbon.

Our work will continue to look at the effects of elevated CO_2 on carbon accumulation in the soil and to study the effects of elevated CO_2 on nutrient cycling. We plan to evaluate ecosystem carbon balance through studies of the acclimation of physiological processes (photosynthesis and dark respiration), ecosystem carbon accumulation (ecosystem gas exchange, allocation of carbon to shoots, root biomass, root development, decomposition, soil respiration, soil microbial activity and soil carbon accumulation by ^{13}C discrimination), resource interactions (water balance and stand level nutrient cycling), plant insect interactions, and the development of a carbon flux ecosystem model.

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